With the application of vasectomy for eugenic, punitive, and therapeutic purposes gaining momentum in the early part of the twentieth century, a new surgical procedure, the vasectomy reversal, was born. The dawn of the vasectomy procedure was marred by dubious scientific and at times overtly sinister elements. Although the history of vasectomy is discussed in another article in this issue, a brief discussion of the development of the vasectomy procedure is pertinent to this discussion of vasectomy reversal.

Vasectomies in the early 1900s were not as they are today, a safe and effective method of voluntary contraception; they often were performed for medically questionable reasons, such as severe prostatic hypertrophy and physical and mental revitalization through the Steinach rejuvenation procedure, and for political motives, such as eugenics and punitive sterilization of criminals. The medical principle of *primum non nocere* was not always followed in the early years of this procedure. The Nazi mass sterilization effort during World War II was merely the culmination of decades of medical demagoguery and misapplication of the vasectomy procedure.

Edward Martin, Chief Surgeon at the University of Pennsylvania during the early years of the past century, although technically he performed vasoe pididymostomies in men who had obstruction secondary to epididymitis, not vasectomy (Fig. 1). In 1902, Martin reported the first vasectomy reversal procedure by the medical and nonmedical communities, including members of religious groups. As of 1948, however, O’Conor observed that most people assumed that reversal surgery was hardly worth considering, given the technical challenges and low success rates. Because urologic surgeons still approached this relatively untested reversal procedure with trepidation and because of the political, religious, and personal implications of vasectomy surgery, men undergoing vasectomy and its reversal often did so under a cloak of secrecy. Furthermore, the legality of this procedure was in question in most states, and urologists performing the surgery were at risk for legal challenges and malpractice suits. In his brief article, O’Conor provides a fascinating glimpse into the practice of male reproductive medicine in post–World War II society.

"FOUNDING FATHER OF MODERN CLINICAL ANDROLOGY"

The birth of the reversal procedure goes back even further than O’Conor’s era. A history of surgical reversal rightfully begins with the work of Edward Martin, Chief Surgeon at the University of Pennsylvania during the early years of the past century, although technically he performed vasoe pididymostomies in men who had obstruction secondary to epididymitis, not vasectomy (Fig. 1). In 1902, Martin reported the first
documented vasoepididymostomy in his study of 192 sterile couples and examination of sperm morphology.\(^7,8\) He initially performed the procedure on three dogs before operating on a man who had obstructive azoospermia.\(^7\) The following year, Martin reported his case of unilateral side-to-side vasoepididymostomy in a man who had a history of epididymitis and gonococcal urethritis, which resulted in sperm in the ejaculate and the birth of a full-term infant.\(^7,9\) After incising the epididymis at a location yielding exudation of milky fluid, Martin constructed the vasal-epididymal fistula using four fine silver wire sutures brought from the outer surface of the vas deferens into the lumen and then through the cut surface of the epididymis and its tunic (Fig. 2).\(^7,9\) In 1909, Martin published his series of 15 azoospermic men who had obstructive lesions, 11 who had epididymal and 4 who had vasal obstruction.\(^7,10\) Possible origins of azoospermia in these men included orchitis (nonobstructive azoospermia), congenital absence of the vasa deferentia, secondary vasal atrophy, long vasal stricture, and distal vasa or ejaculatory duct obstruction.\(^7\) Martin performed vasoepididymostomies in the 11 men who had epididymal obstruction using the same technique described in his previous publication, with patency and pregnancy rates of 64% and 27%, respectively.\(^7\) Not only did Martin demonstrate the effectiveness of the reconstructive procedure for obstructive azoospermia but also he observed that azoospermia can be obstructive and nonobstructive.\(^7\) Martin’s clinical acumen was remarkable, and his observations seem to fit current standards of reproductive medicine rather than those of 1909. He even checked vasal patency during the vasoepididymostomy procedure, foretelling today’s use of vasography. The significance of his contributions to the field of male infertility inspired Jequier to entitle Martin the “founding father of modern clinical andrology” in her profile piece.\(^7\)

Francis Hagner of Washington, DC, was an early proponent of Martin’s surgery. In 1907, Hagner reported at the twenty-first annual meeting of the American Association of Genito-Urinary Surgeons two cases of successful anastomosis between the vas deferens and the globus major; one surgery had been performed by Martin and the other by Hagner.\(^11\) The surgery was performed with fine silver wire and curved intestinal needles, and the vas deferens was anastomosed to the epididymis after observation of white fluid exudation from a small wedge-shaped incision in the globus major. Sperm was detected in the ejaculate at 1 month. Hagner’s continued success with the vasoepididymal anastomosis helped popularize the procedure.\(^12\) In 1936 he reported patency and pregnancy rates of 64% and 48%, respectively, in 33 patients undergoing vasoepididymostomy.\(^13\)
Hagner's technique was modified and used by Hanley in Great Britain and Bayle in France.\textsuperscript{12,14,15}

**CAPACITY FOR REGENERATION**

H. C. Rolnick was another Chicago urologist at Northwestern University Medical School who contributed to the development of vasectomy and reconstructive surgery. In 1924, he published his series of 48 vasal surgeries in 25 dogs, in which he ligated, incised, or resected the vasa to determine their regenerative capacity.\textsuperscript{16} In the five dogs in which both vasa were ligated with catgut suture, all vasa were patent when checked after 21 to 38 days. In one of the dogs, the left vas deferens was sutured to the skin and a horsehair was left in the lumen, but this did not prevent patency. When Rolnick made multiple longitudinal and oblique incisions of the vasa, three of five were patent. Multiple transverse incisions of the vas always resulted in occlusion of the lumen. When six vasa were divided and separated from the sheath, however, no patency was observed. In contrast, six of seven vasa achieved patency when divided without disturbing the sheath or deferential vessels. Foreign body or suture in the lumen did not cause occlusion. In several dogs, Rolnick performed reversal surgery of the divided vasa and achieved patency in five of 13 anastomoses. From these results, he concluded that the vas deferens had the ability to resist trauma and restore its luminal patency and the intact vasal sheath and deferential vessels play an important role in the restoration of vasal integrity after injury.

**VASOVASOSTOMY**

In 1919, Quinby reported the first successful vasovasostomy in a man who had undergone bilateral vas resection in 1911.\textsuperscript{6} He created the anastomosis over a strand of silkworm gut, which was removed after 10 days.\textsuperscript{17} Quinby’s assistant for this historic procedure was none other than O’Conor. O’Conor subsequently used Quinby’s technique in 14 vasectomized patients, resulting in a patency rate of 64%.\textsuperscript{6} In the same article published in 1948, O’Conor reported the results of his survey of 1240 urologists on the topic of vasectomy reversals. Seven hundred fifty urologists completed the questionnaire, and only 135 had any experience with the procedure. Of the 420 reported operations, patency rate was 38%, although the rate of spontaneous recanalization of the vasa was not determined.\textsuperscript{6} Several such surveys have been conducted in the ensuing decades, and this report provides the first snapshot of clinical practice patterns for vasectomy reversal surgery.

By the 1970s, many reports on macrosurgical techniques for vasovasostomy began appearing in the literature. Hulka and Davis reviewed vasovasostomy series from the United States, India, and Denmark and compiled 705 cases. They found a patency rate of 60% and a pregnancy rate of 44% in series reporting pregnancies.\textsuperscript{18} The investigators discussed pertinent anatomic considerations, such as the average luminal diameter of the vas deferens (0.55 mm) having significant variation and pondered whether or not ligation of the sympathetic nerve fibers of the inferior spermatic nerve during vasectomy resulted in permanent impairment of sperm transport through the vas deferens.\textsuperscript{18} They also reviewed methods for reversible vasocclusion, including use of prosthetic plugs with injections of Silastic and other nonreactive synthetic materials, an intra vas device similar in theory to the intrauterine device, and the vas clip and vas valve.\textsuperscript{18} Even within the confines of this scientific review article, hints of the broader political and social context of vasectomy and vasectomy reversal during the 1970s surfaced, with references to the zero population growth movement and allusions to the second wave of the feminist movement.\textsuperscript{18} Interest in vasectomy flourished during this time because of increased interest in family planning by men and the emancipation of women.\textsuperscript{18} With the increasing popularity of vasectomy, the relevance of vasectomy reversals inevitably followed.

In 1973, Getzoff published another questionnaire study of 150 urologists, examining their views and management of reversal surgery.\textsuperscript{19} On the topic of vasoepididymostomy, 13.3% had never performed this procedure, 28% had had no success, 20.7% rare (1%) success, 21.3% occasional (5%) success, 14% moderate (20%) success, and 2.7% moderately encouraging success (50% to 70% reported in the literature). When indications for a vasoepididymostomy were present, 9.3% urologists encouraged the operation, 27.3% discouraged it, and 63.3% had discussions with the patients about the procedure and prognosis. The same questions were asked regarding vasovasostomy, and 6% had never performed this procedure, 8% had had no success, 11.3% rare (1%) success, 20% occasional (5%) success, 38.7% moderate (20%) success, and 16% encouraging success (50% to 70% reported in the literature). When a patient presented for a potential vasovasostomy, 8.7% urologists encouraged the operation, 5.3% discouraged it, and 86% had discussions about the procedure and prognosis. Sixty-two percent believed a second procedure should not be attempted if the initial reversal surgery failed. Regarding
surgical technique, no splint was used in 9.9% of cases, silver wire in 51.1%, nylon suture in 33.8%, Silastic tubing in 9.5%, steel wire in 3.2%, silk suture in 0.8%, and other splints in 1.6%. Compared with the results from O’Con-or’s survey in 1948, there was a dramatic increase in the proportion of urologists who had at least some experience with reversal surgery. Perhaps more telling is the stark contrast between the published success rates in the literature (50% to 70%) and the low success rates in actual clinical practice.

ETIOLOGIES OF VASECTOMY REVERSAL FAILURE

Since the early studies of Rolnick, several groups have studied the causes of reversal surgery failures. Failures can be functional or anatomic.

**Functional Failure: Agglutinating Antibodies**

Sullivan and Howe tested the serum of 45 men who had sperm in their ejaculate after reversal surgery and found agglutinating antibodies in 48% of those whose partners became pregnant and in 94% of those whose partners did not (P < .01).20 The investigators did not believe, however, autoagglutination to be the mechanism for immunologic infertility in functional reversal failures because almost half of fertile men had the antibodies, autoagglutination of sperm was not seen in any of the study patients, and previous evidence had demonstrated in a rabbit model that immunologically induced sperm agglutination is neither necessary nor sufficient for sperm deactivation.20 In contrast, Requeda and colleagues21 concluded that sperm antibodies are an important cause of infertility in men who have undergone reversal surgery. In their study, six of eight fertile reversal patients had low titers of serum agglutinins, normal fertilizing capacity of their sperm, and no immobilizing antibodies, whereas six of seven infertile reversal patients had elevated serum agglutinins and four had agglutinating antibodies in seminal plasma and serum immobilizing antibodies.21

**Anatomic Failure: Sperm Granuloma**

The effect of sperm granulomas on reversal surgery outcomes also has been evaluated. Working with a dog model, Schmidt determined that causes of vasovasostomy failure included sperm granuloma formation resulting from anastomotic leakage of sperm secondary to inadequate approximation of the vasal ends, puncture of the vasal lumen, misalignment of the anastomosis, and infection.22 Hagan and Coffey performed 119 vasovasostomies on 95 rats and found that sperm granulomas were present in 99% of the 49 failed anastomoses.23 They also performed vasal anastomoses in immature animals or in adult animals with suppression of spermatogenesis with testosterone and achieved 95% patency without granulomas.23 Alexander and Schmidt reported that more men who had sperm granulomas had sperm-immobilizing antibodies.24

A healthy, patent epididymis is the cornerstone of successful vasectomy reversal surgery. Silber microsurgically explored the epididymis of 28 men undergoing vasectomy reversal who were found to have no sperm in the vasal fluid of the testicular side of the vas deferens.25 Sperm was found in 33 of 39 epididymides and histologic evaluation distal to the area with sperm revealed extensive interstitial sperm granulomas resulting from epididymal duct rupture.25 He concluded that persistent azoospermia after vasovasostomy resulted from secondary epididymal obstruction due to epididymal duct rupture from increased pressure after vasectomy.25

Functional and technical problems do not account for all reversal failures. Continued infertility after surgery may be unrelated to surgical technique. For example, the epididymis also is important because of its role in sperm maturation. Schoysman and Bedford reported a greater chance of pregnancy after vasoepididymostomy with anastomosis to the corpus instead of the caput, with motility the only sperm characteristic affected.26 In most men whose anastomosis was located 8 mm or less from the proximal border of the caput, sperm were immotile.26 In contrast, 20% to 90% of sperm were progressively motile in cases where the anastomosis were greater than 10 mm from the caput border.26

MACROSURGICAL TECHNIQUE

A wide range of macrosurgical techniques for vasovasostomy has been reported. The main variation in technique seems to be the use or omission of loupe magnification and stenting. Stenting is the use of a suture, tube, or other foreign body to help keep the lumen of the vas deferens open after a reversal procedure. Stents usually but not always are removed during the postoperative period.

Amelar and Dubin favored a nonstented technique with 4x loupe magnification using eight 6-0 Prolene sutures.27 Once the vas is exposed and the scarred ends are excised, the distal vas is cannulated with a blunt needle and tested for patency by injecting hydrogen peroxide dyed with methylene blue.27 Fluid from the proximal
vas is examined with microscopy for the presence of sperm. These investigators used a stent to assist during the anastomosis but did not leave the stent in place to aid in healing. A 2-0 nylon suture is used as a stent during the creation of the anastomosis with the eight 6-0 Prolene sutures and is always removed before closure. This procedure is similar to the Schmidt operation, from which many of the derivative techniques have been adapted.

In contrast, Dorsey described a stented technique without magnification. He used a blunt 20-gauge needle with obturator to pierce the wall of the proximal vas, 1 centimeter from the site of anastomosis and the fascia, dartos, and scrotal skin. A zero monofilament dermalon suture is fed through the needle and the other end of the suture is advanced 12 to 14 cm into the distal vas segment. The anastomosis is formed over the stenting suture with four or five 6-0 Ethiflex sutures. The dartos layer is closed with a running 3-0 chromic suture. The stenting suture is exteriorized through two lead shots, and the shots are crimped in place. Stent, therefore, is the more accurate descriptor in this context. The use of exteriorized stents has several potential disadvantages, including infection and sperm leakage. Stents can provide a portal of entry for bacteria and serve as a foreign body to perpetuate the infection. Montie and colleagues tested in a canine model the feasibility of a completely intravasal stent using absorbable suture that does not require postoperative removal. Nineteen dogs underwent vasovasostomies with and without intravasal stents. The group without intravasal stents had a patency rate of 50% compared to 60% patency in the Dexon intravasal stent group and 70% patency in the chromic intravasal stent group.

TO STENT OR NOT TO STENT

Although “stent” and “splint” have been used interchangeably in the literature to describe the use of a foreign material to encourage patency of the vasal lumen during the time of epithelialization of the anastomosis, Montie and colleagues pointed out that a splint refers to something placed outside a structure to stabilize it whereas a stent is a compound for holding some form of graft in place. The disadvantages of stents were reported, including Fernandes and colleagues’ demonstration in dogs that obstruction often occurred at the site of exit of the stent through the vas deferens instead of at the anastomosis. As surgical technique improved with the widespread availability of microsurgery, stents gradually disappeared from reversal surgery.

MICROSURGICAL TECHNIQUE

Owen and Silber, working independently, are credited with the development of the microsurgical vasovasostomy technique for clinical use. The use of the microscope for the anastomosis of the vas deferens in animals had been previously evaluated by several groups. The earliest reference to microsurgical vasovasostomy in humans was by Silber in 1975. Most of the initial
animal studies involved a one-layer anastomosis, but Silber determined that in humans a two-layer is preferable largely because of the discrepant luminal diameters due to dilatation of the proximal vas segment. Silber performed the anastomosis under $16 \times$ to $25 \times$ magnification using single-armed 9-0 nylon sutures (Fig. 3). He dilated the abdominal portion of the vas deferens with the insertion of jeweler’s forceps. The mucosal sutures included the elastic layer subjacent to the mucosa. After placement and tying of the three anterior sutures, the clamp is flipped to visualize the posterior wall of the anastomosis. He advocated careful inspection for gaps, tears, or inaccuracy of the lineup after placement of the six or seven mucosal sutures. The outer muscularis layer is then sutured separately. The two-layer technique allows for superior mucosal approximation and leakproof closure. Silber and colleagues performed histologic and electron microscopic studies and found that stricture was a common cause of failure with conventional or nonmicroscopic vasovasostomies and that obstruction of the vas deferens inhibited spermatogenesis. Further refinements to this microsurgical technique have been made over the years, including Goldstein’s introduction of the microspike approximator clamp (Fig. 4) and use of microdots for precision suture placement. By providing a blueprint for the anastomosis, the dots minimize gaps and distortions of the anastomosis even with discrepant sizes of the cut vasal ends (Fig. 5).

In 2004, Silber and Grotjan summarized their experience with 4010 cases of microscopic vasectomy reversal. Of 1357 patients undergoing microsurgical vasovasostomy, patency was achieved in 94.4%. Of 1008 patients undergoing unilateral vasoepididymostomy (with contralateral vasovasostomy) and 1013 patients undergoing bilateral vasoepididymostomy, patency rates were 93.7% and 78.7%, respectively.

In 1980, Lee and McLoughlin reported their comparison of macroscopic and microscopic vasovasostomy techniques. The macroscopic anastomoses were performed with a nonabsorbable monofilament internal stent, which was removed 7 to 14 days postoperatively and four to six absorbable sutures sized 4-0 to 6-0. The microsurgical anastomoses were performed in two layers using 8-0 to 10-0 synthetic suture. For the 61 patients undergoing the single-layer macroscopic procedure, patency and pregnancy rates were 90% and 46%, respectively. For the 26 patients undergoing the two-layer microscopic procedure, the rates were 96% and 54%, respectively. The investigators reported 100% patency and an 88% pregnancy rate in patients undergoing reversal surgery less than 2 years after the initial vasectomy and postulated importance of the 2-year period. Similarly, Silber had previously

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Fig. 3. The steps in Silber’s microscopic technique of vasovasostomy. (A) The lumen is inspected for patency. (B, C) Mucosal anastomosis. (D) Separate anastomosis of muscularis. (From Silber SJ. Microscopic technique for reversal of vasectomy. Surg Gynecol Obstet 1967;143:631, copyright Elsevier; with permission.)
reported in 1977 the importance of duration of obstruction, with improved patency rates in those undergoing reversal surgery less than 10 years from the original vasectomy. Although opinion of the precise time interval between initial vasectomy and subsequent reversal has since changed, Lee and McLoughlin recognized the significance of the time interval to reversal outcomes. In 2004, Boorjian and colleagues reassessed obstructive intervals and determined that the pregnancy rate was significantly lower in those whose vasectomy had been performed more than 15 years before reversal surgery. Pregnancy rates were 89%, 82%, and 86% for obstructive intervals of 0 to 5, 5 to 10 and 10 to 15 years, respectively, compared to 44% for obstructive intervals greater than 15 years. Furthermore, Fuchs and Burt reported that spousal age is an important predictive factor after vasectomy reversal when surgery is performed 15 years or more after vasectomy.

The impact of the obstructive interval has been addressed by another important series published by the Vasovasostomy Study Group in 1991. The Vasovasostomy Study Group was a consortium of five institutions that pooled data for a 9-year period for a total of 1469 microsurgical vasectomy reversal procedures. Of the 1012 men who underwent reversal surgery for the first time and presented for postoperative semen analysis, 865 (86%) achieved patency. Four hundred twenty-one (52%) of 810 couples achieved pregnancy. The patency and pregnancy rates declined as the interval between the vasectomy and the reversal surgery increased: 97% and 76%, respectively, for interval less than 3 years, compared to 71% and 30%, respectively, for intervals greater than 15 years.

In 2004, Crain and colleagues published another questionnaire study on the practice patterns of vasectomy reversal surgery among practicing urologists and highlighted the significance of obstructive intervals. They received 622 completed questionnaires from 1508 mailed. Of the 59% who performed vasectomy reversals, 8% were fellowship trained in infertility, 23% were affiliated with residency training, and 69% practiced in a community setting, with fellowship-trained urologists performing more reversal procedures per year than the others. Fellowship-trained urologists also were more likely to perform surgery on patients greater than 15 years since vasectomy. Compared with the other two groups, they also were more likely to use the operating microscope (93% versus 65% and 56%) and examine the vasal fluid (83% versus 75% and 67%) and to use finer suture material.

ONE LAYER OR TWO?

Microsurgical vasovasostomy began as a double-layer technique and was quickly established as the gold standard. As with all surgical procedures, however, modifications were promoted as improvements on the original. Inevitably, several groups promoted the single-layer technique as a simpler alternative. Schroeder-Printzen and colleagues reviewed the outcomes for several series of double-layer and single-layer reversal surgeries. Patency and pregnancy rates (mean ± SD) in 12 series comprising 2183 cases of double-layer vasovasostomies were 87% ± 13 and 52% ± 17, respectively. In four series of single-layer vasovasostomies with 185 cases, patency and pregnancy rates (mean ± SD) were 90% ± 8 and 53% ± 10, respectively. They also reviewed five series in which the two techniques were compared. Patency and pregnancy rates (mean ± SD) for 724 single-layer cases

Fig. 4. The slotted nerve holding clamp for making a perfect 90° transection of the vas deferens. (Courtesy of Marc Goldstein, MD, New York, NY.)

Fig. 5. A photograph of the microdot technique of precision suture placement, demonstrating the large lumen of the testicular vas and the small lumen of the abdominal vas. (Courtesy of Marc Goldstein, MD, New York, NY.)
were 89% ± 8 and 56% ± 12, respectively, and 91% ± 5 and 57% ± 12, respectively, for 902 double-layer cases. It is difficult to draw conclusions from these data, as the constituent studies had heterogeneous methodology, patient populations, and surgeon experience. Outcomes reported by the Vasovasostomy Study Group for double-layer and modified single-layer anastomoses were statistically the same.

VASOGRAPHY
Vasography had been in use for many years, as far back as 1909 by Martin (discussed previously). Although Martin used vasography to confirm patency of the distal vas deferens before performing an anastomosis of the vas deferens to the epididymis in a similar fashion to vasograms of today, vasography also has been used to test the anastomosis, more in line with the use of vasograms in a laboratory setting or microsurgical training.

In 1982, Hartig and Meyer assessed the safety of intraoperative vasography at the time of vasovasostomy. They evaluated the use of vasography in 11 cases when dissatisfaction with the appearance of one of their anastomosis prompted them to perform an intraoperative vasogram. They used the vasogram technique described by Paulson and coworkers, which involved gentle injection of 6 mL of contrast material into the vas deferens. A radiograph was obtained simultaneously with the injection and the film was evaluated for demonstration of contrast material across the anastomosis. No complications were observed, and all patients had return of sperm in their ejaculates. This contrasted with the experience of Jenkins and Blacklock, who performed intraoperative vasography in one patient who developed a mild postoperative epididymitis.

VASOEPIDIDYMOSTOMY
Vasoepididymostomy techniques can be broadly categorized as “fistula formation” based on Martin’s original technique or “tubule-to-tubule” as described by Silber. As Thomas pointed out, although Silber generally is credited for the single tubule-to-tubule anastomosis, Lespinasse had a similar idea 60 years earlier, wherein a 5-0 silk suture was passed through a single epididymal loop and the mucosal surface of the vasal lumen.

In 1978, Silber described his technique involving the direct end-to-end anastomosis of the inner lumen of the vas deferens to one epididymal tubule. The epididymis is inspected under 10× to 16× magnification, allowing for identification of tubules dilated to 0.1 to 0.2 mm in diameter secondary to obstruction. Approximately 1 cm of the epididymis is dissected from the testis, and the vas deferens is prepared in the same fashion as for a vasovasostomy. Under 16× to 25× magnification, the epididymis is transected completely at the lowest point, and, although multiple epididymal tubules are cut, the appropriate tubule is selected by efflux of sperm fluid with microscopy to check for presence of sperm. If no efflux of sperm fluid is encountered, another transection of the epididymis is made 0.5 cm proximal to the previous cut. So by trial and error, the epididymis is sequentially sampled from the distal portion to the proximal portion. The anastomosis is created using interrupted 9-0 or 10-0 nylon sutures, with the first two sutures placed posteriorly from the outside in on the epididymal tubule. These sutures then are placed from inside the mucosa of the vas deferens to the outside and tied. The two anterior sutures are placed in a similar manner. The muscularis of the vas deferens is approximated to the epididymal tunic using 10 to 12 9-0 nylon sutures to provide stability for the delicate mucosal anastomosis. In his preliminary group of 14 patients, 12 (86%) had sperm counts of greater than 20 million per mL. In a follow-up study, Silber observed that patients who had undergone microsurgical vasoepididymostomy of the proximal (head) region of the epididymis had poor sperm motility, which improved within 1.5 to 2 years.

Many variations of this end-to-end anastomosis have been developed, but the end-to-end approach gradually fell out favor with the advancement of end-to-side techniques, in which a single epididymal loop is isolated and the anterior wall of the loop is unroofed for the anastomosis to the vas deferens. Resection of the epididymis for end-to-end anastomosis can result in bleeding and difficulty identifying a patent tubule. Wagenknecht was one of the early advocates of the end-to-side technique. In 1998, Berger published his triangulation end-to-side technique, which involves placement of three double-armed 10-0 nylon sutures into the epididymis so that each suture forms one side of a triangle. An opening is made in the epididymal tubule and the sutures are brought inside-out, invaginating the tubule into the vasal lumen. Ninety-two percent patency was achieved in 12 men with this technique. In 2003, Chan and colleagues introduced the two-suture longitudinal technique, in which two double-armed 10-0 nylon sutures are placed longitudinally along the anterior surface of a single epididymal tubule. The needles are pulled through only after the tubular opening is made. The
sutures are placed into the vas deferens from inside out at four points and, when the sutures are tied, the epididymal tubule intussuscepts into the vasal lumen. Using a rat model, the group reported comparable outcomes for this technique compared with other two or three suture intussusception vasoepididymostomy techniques, with the advantage of a larger opening in the epididymal tubule and shorter operative time.90

REVERSAL SURGERY IN THE AGE OF ASSISTED REPRODUCTION

Despite progress over the years with vasectomy reversal, the introduction of intracytoplasmic sperm injection (ICSI) led many to wonder if technically challenging microsurgical vasectomy reversals were worth the trouble. There are several important advantages to reversal surgery, including treatment of an affected man instead of his healthy partner, natural conception through sexual intercourse, and the ability to father more than one child after one procedure. If an experienced microsurgeon is available, the biggest downside to reversal surgery is the length of time for return of sperm to the ejaculate, which can take 6 months to 2 years or longer.68 In the fast-paced modern era, time is of the essence, and many fertility clinics bypass consideration of reversal surgery. Comparisons of reversal surgery to ICSI have been studied, however, and the results usually favor reversal surgery. Pavlovich and Schlegel conducted a cost-effectiveness analysis of vasectomy reversal and ICSI and determined that cost per delivery with an initial approach of vasectomy reversal was $25,475 (95% CI, $19,609 to $31,339) with a delivery rate of 47% compared with cost per delivery after sperm retrieval and ICSI of $72,521 (95% CI, $63,357 to $81,685) with a delivery rate after one cycle of sperm retrieval of 33%.91 Microsurgical reversal surgery provided the most cost-effective treatment for postvasectomy infertility and the highest chance of resulting in delivery of a child for a single intervention. Kolettis and Thomas concurred that vasoepididymostomy is more successful and cost-effective than ICSI with retrieved sperm.92

THE FUTURE?

Surgical procedures are forever evolving, whether or not it is a simplification of mechanics or the application of new technology, surgeons always are looking for ways to streamline an operation and to nudge up success rates while reducing complications. Because suturing of the anastomosis is the most technically challenging step in the vasectomy reversal procedure, a wide variety of sutureless anastomatic techniques has been evaluated, including laser welding,93,94 microclip,95 fibrin glue96,97 and other biomaterials as surgical sealants.98 Sutureless techniques are still in the experimental stage with animal studies, and some time may pass before a suitable biomaterial is available for clinical use.

Urology has entered the robotic age. The da Vinci robotic system has captured the imagination of the public, enraptured by the space age concept of having a cancerous organ removed by a hulking but benevolent robot under the remote control of a genius scientist cum surgeon. Will reversal surgery follow urologic oncology down the technology path? Perhaps. Several groups have considered this possibility, including Schiff and colleagues,99 who randomized 24 rats to undergo microsurgical multilayer vasovasostomy, longitudinal vasoepididymostomy or robotic vasovasostomy, and vasoepididymostomy. To perform the robotic procedure, the anastomosis was set up using a conventional operating microscope and transferred to the robotic field to undergo the anastomosis. Patency rates were 100% for the robotic approach and 90% for the microsurgical approach (no statistical difference). Robotic vasovasostomy was significantly faster than conventional microsurgical technique, 68.5 versus 102.5 minutes (P = .002). The investigators concluded that the robotic approach improved stability and motion reduction and provided the potential for microsurgeons to perform reversal surgery in patients at remote locations lacking access to experienced microsurgeons. Advances in medical technology always are tempered, however, by cost considerations. The cost-effectiveness of the application of robotic technology to infertility surgery remains to be determined.

SUMMARY

Vasectomy reversal has come a long way since Martin performed the first anastomosis of the vas deferens and epididymis. Although its history is not as politically charged as that of vasectomy, the progress of reversal surgery has had its share of ups and downs, brilliant discoveries, and discouraging missteps (see Appendix). In the early part of the twentieth century, vasovasostomy and vasoepididymostomy were esoteric procedures, but by the 1970s, a majority of urologists had at least some experience with reversal surgery, although not as successfully as reported in the literature. With the advent of the microsurgical technique, reversal surgery increasingly has
become once more a specialist’s undertaking. The
history of vasectomy reversal is an excellent case
study in the evolution of surgery, rich with leaders,
inventors, and pioneers.

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We thank Vanessa Lynne Dudley for creating the
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APPENDIX: TIMELINE OF THE HISTORY OF REVERSAL SURGERY

Timeline of the History of Reversal Surgery: 1823 - Present

- English surgeon and anatomist Sir Astley Cooper
  performs a canine vasectomy and notes at necropsy
  one year later that the epididymis is enlarged and
  full of sperm. 6

- Martin reports the first vasoepididymostomy with
  a macroscopic fistula technique. 4

- Chicago urologist Dr. Victor Darwin Lepinsasse
  performs a vasoepididymostomy with single
  tubule anastomosis. 8

- Dr. H. C. Rolnick of Chicago publishes on
  the natural regeneration of luminal patency in vasa
  deferentia that has been ligated, incised or
  resected. Intact vascular sheath and deferential
  vessels are important to the regeneration process. 27

- Dr. J. E. Strode attempts unilateral vasal
  anastomosis in two patients who had undergone
  vasectomies in 1930 - motile sperm in the
  ejaculate is achieved by one of the patients. 35

- Chicago urologist Dr. Vincent O’Conor reports
  the presence of sperm in the ejaculate of nine of
  14 patients undergoing reversal surgery with
  Quinby’s technique.

- O’Conor reports that only 135 of 1240 surveyed
  urologists have performed the reversal procedure
  at least once. A 35 - 40% success rate is reported
  for 420 operations. 24, 31

- Phadke and Phadke report an 83% patency rate
  and 55% pregnancy rate in 76 patients using a
  macrosturical technique using 6-0 arterial silk
  over an internal splint with thin nylon thread. 28, 37

- First anastomosis of the vas deferens and epididymis is
  attempted by Philadelphia surgeon Dr. Edward Martin.
  33, 37

- Boston urologist Dr. William C. Quinby reports the first
  successful vasovasostomy. He reunites the left vas
  deferens in a patient who had undergone bilateral vas
  resection in 1911. He performs the anastomosis over a
  strand of silkworm gut which is removed after ten days.
  24, 37

- Dr. Francis Hagner of Washington, D.C. proclaims great
  success with his vasoepididymostomy technique, with
  patency rates of 60% and 40%, respectively, helping to
  popularize reversal surgery in the United States and the
  world. 15, 16

- Freiberg and Lepsky present a case report of a successful
  unilateral side-to-side anastomosis using silk sutures on a
  man who had a vasectomy eight years previously. 10

- Massey and Nation observe that sperm counts can
  continue to improve for at least a year following reversal
  surgery. 37

- Rosenbloom writes of the value of loupe-magnification
  in preparing and anastomosing the vas ends. 28

- Fernandes et al. report on their experience with
  microsurgical vasovasostomy in dogs. Vasograms
  confirm success in two of 21 anastomoses performed
  using a wire splint and 19 of 20 anastomoses performed
  without a splint. 9
APPENDIX: REFERENCES


REFERENCES


85. Lespinasse VD. Obstructive sterility in the male. Treatment by direct vaso-epididymostomy. JAMA 1918;70:448.